Final Report

Little Calumet and Portage Burns Waterway TMDL for *E.coli* Bacteria, and Cyanide

Source Identification and Assessment Report

Prepared for the

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1. INTRODUCTION

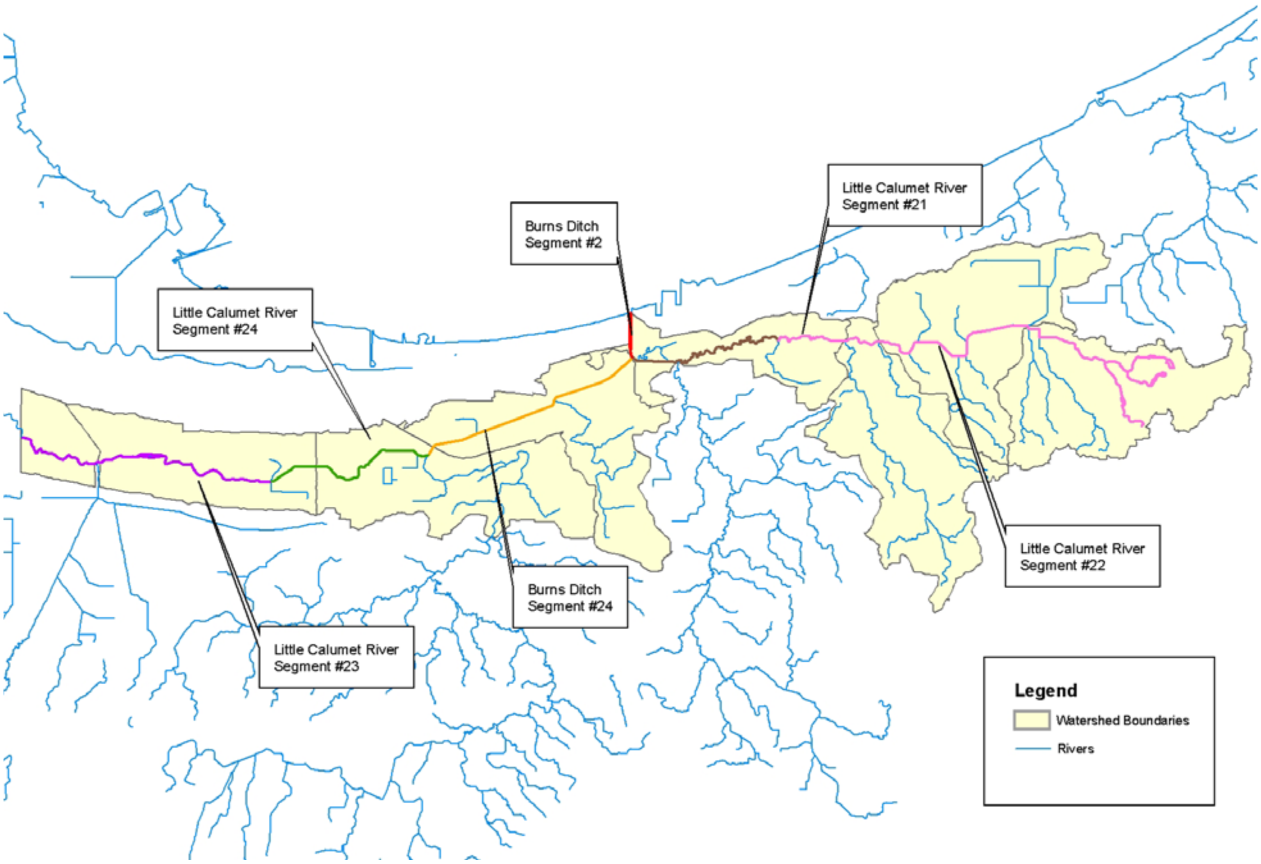
Table 1 lists the impaired stream segments of the Little Calumet – Burns Ditch (Figure 1), for which TMDLs will be developed.

TABLE 1
STUDY REACHES AND PARAMETERS

Water Body	Segment Number	Location	Impairment
Burns Ditch	2	Confluence of East Branch LCR and Burns Ditch North, in Porter County	*E. coli*
Burns Ditch	24	Burns Ditch west to Deep River, just east of I-65 in Porter and Lake Counties	*E. coli*
Little Calumet	21	Confluence of the West Branch of LCR and Burns Ditch east to an unnamed tributary, just west of Hwy 20 in Porter County	*E. coli*
Little Calumet	22	Unnamed tributary east including headwaters of the stream in Porter and LaPorte Counties	*E. coli*
Little Calumet	23	Black Oak to Illinois, in Lake County	Cyanide
Little Calumet	24	Deep River west to Black Oak, between SR 912 and SR 53	*E. coli* & Cyanide

This report examines the documented sources of *E.coli* and cyanide in the Little Calumet River and Portage Burns Waterway system. Loads are characterized by using the best available information, such as monitoring data and literature values. This report describes the available information and provides an interpretation of the data. The following sections are organized so that they describe which facilities could have an impact on the *E.coli* impairment and which may have an impact on the cyanide impairment.

FIGURE 1
STREAM SEGMENTS LITTLE CALUMET RIVER AND PORTAGE BURNS WATERWAY



2. ASSESSMENT OF POINT SOURCES

2.1 Inventory of NPDES Facilities

There are eight NPDES facilities that discharge directly into Little Calumet River and/or Portage Burns Waterway (Table 2A) and fifteen NPDES facilities that discharge into tributaries of the rivers (Table 2B). Figure 2 shows the location of each of the NPDES facilities. The tables also indicate whether they are classified as major facilities, that discharge 1.0 or greater million gallons per day, or minor facilities, discharge less than 1.0 million gallon per day.

Facility INU060801 (Burns Harbor and Bethlehem Steel) is not shown in Figure 2 because the effluent from this facility is through Bethlehem Steel (IN0000175). The Town of Porter WWTP (INU046949) is also not included on Figure 2. This facility does not have any discharge. Instead, all of its flow goes to the Chesterton Sewage Treatment Plant (IN0022578). In addition, there are two major and eight minor NPDES facilities that are in the Salt Creek basin.

TABLE 2A
LITTLE CALUMET-BURNS DITCH NPDES FACILITIES

NPDES Facility ID	Facility Name	Major Minor	Receiving Water
ING080159	Wolverine Pipeline Company	Inactive	Little Calumet River via groundwater
IN0000175	Bethlehem Steel Corporation	**Major**	Little Calumet River and Burns Harbor
INU060801	Burns Harbor and Bethlehem Steel	Minor	Little Calumet River via Bethlehem Steel
IN0022578	Chesterton Municipal STP	**Major**	Little Calumet River to Lake Michigan
IN0000337	National Steel, Midwest Division	**Major**	Burns Ditch to Lake Michigan
IN0024368	Portage Municipal STP	**Major**	Burns Ditch to Lake Michigan
INU046949	Town of Porter WWTP	Minor	Little Calumet River East Branch
IN0043435	Praxair, Burns Harbor Facility	Minor	Little Calumet River to Lake Michigan

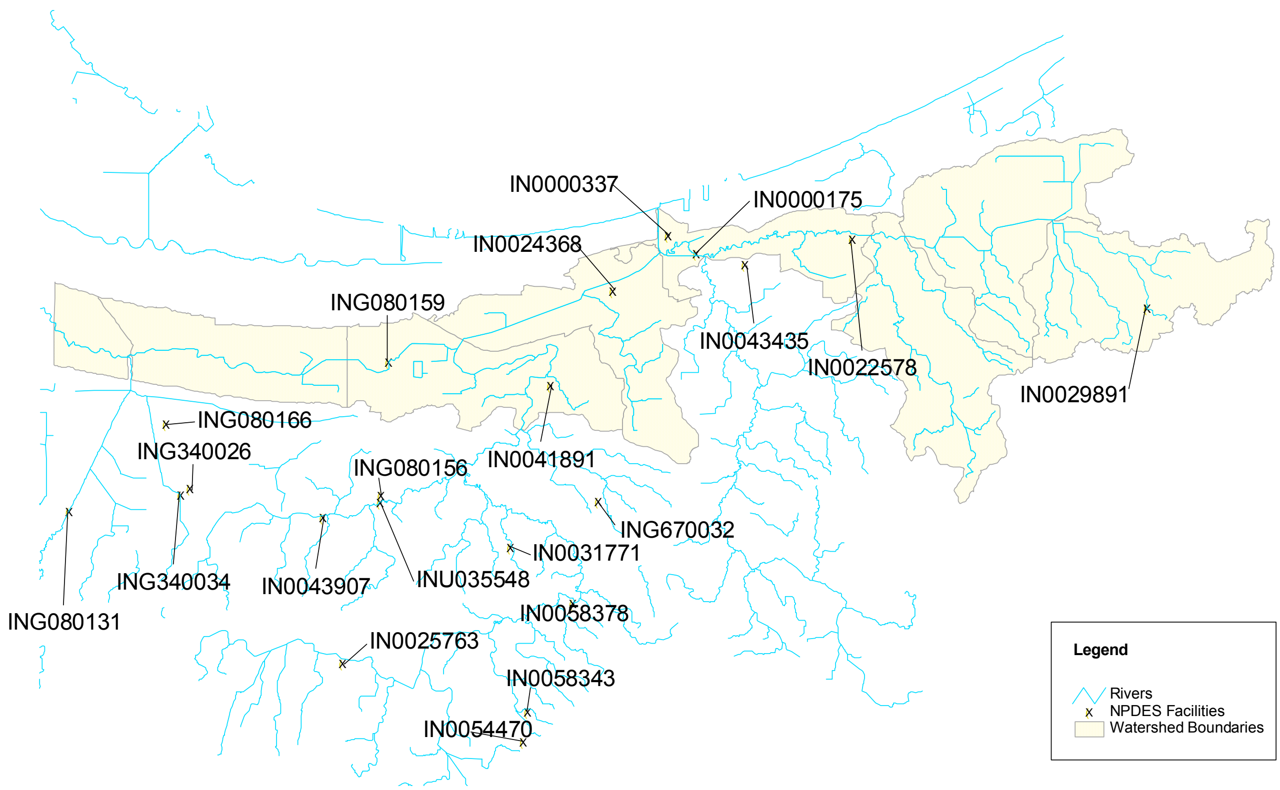
TABLE 2B
TRIBUTARY NPDES FACILITIES

NPDES Facility ID	Facility Name	Major Minor	Receiving Water
IN0041891	Nob Hill Subdivision	Minor	Deep River via Unnamed Tributary
ING080131	Transmontaigne Pipeline, Dyer	Minor	Little Calumet River via Plum Creek
ING340034	Lakehead Pipeline, Hartsdale	Minor	Turkey Creek via Spring Street Ditch
ING340026	Teppco-Griffith Terminal	Minor	Turkey Creek via Unnamed Drainage Ditch
IN0043907	Merrillville Conservation District (Formerly owned by Community Utilities of Gary)	Minor	Turkey Creek to Deep River to Little Calumet River
INU035548	Merrillville C.D. WWTP	Minor	Turkey Creek via Lift Station Overflow
ING670032	Nisource Crossroads Pipeline	Minor	Peregrine Ditch to Duck Creek to Deep River
ING080156	Coastal Service Station	Minor	Lake George via Turkey Creek via Storm Sewer
IN0029891	Purdue University North Central	Minor	Unnamed tributary to the Little Calumet River
IN0025763	Crown Point Municipal STP	**Major**	Deep River via Beaver Dam Ditch
IN0031771	John Wood Elementary School	Minor	Unnamed tributary to Deep River
IN0054470	Chicagoland Christian Village	Minor	Unnamed tributary to Deer Creek to Deep River
IN0058343	Winfield Township WWTP	Minor	Unnamed tributary to Deer Creek to Deep River
IN0058378	Deep River Water Park WWTP	Minor	Deep River to Little Calumet River
ING080166	Speedway Service Station #8338	Minor	Storm Drain to Caddy Marsh Ditch to Hart Ditch

2.2 Point Sources Contributing to the *E.coli* Impairment

Of the eight NPDES facilities discharging into segments of the Little Calumet River and Portage Burns Waterway (Table 2A), seven are considered to contain *E. coli*. Seven discharge wastewater to the Little Calumet River and Burns Ditch. The remaining one, Praxair (IN0043435) discharges a chlorinated water discharge, which is not considered a source of bacteria. Three facilities in Table 2A are considered municipal sources and five are considered industrial sources. The following sections describe the average concentrations released by these facilities.

FIGURE 2
NPDES FACILITIES LOCATIONS



2.2.1 Industrial Point Sources

Only three industrial facilities (Table 3) that discharge into the Little Calumet River and lower reaches of Burns Ditch have discharge limits for bacteria. None of the facilities are currently required to monitor their discharge for *E.coli*. Instead they monitor for fecal coliform. Table 3 lists the permit limits for these facilities.

TABLE 3
INDUSTRIAL NPDES FACILITIES' PERMIT LIMITS

NPDES No.	Facility Name	Daily Average Fecal Coliform (#/100 ml)	Daily Maximum Fecal Coliform (#/100 ml)
IN0000175	Bethlehem Steel Corporation	200	400
INU060801	Burns Harbor and Bethlehem Steel	200	400
IN0000337	National Steel, Midwest Division	200	400

Using the discharge monitoring reports, Table 4 lists the characteristics of the effluent of the three industrial facilities.

TABLE 4
INDUSTRIAL NPDES FACILITIES'
REPORTED DISCHARGE CHARACTERISTICS

NPDES No.	Facility Name	Reporting Dates	Ave. Monthly Conc. Fecal Coliform (#/100 ml)	Ave. Max. Wkly/Dly Conc. Fecal Coliform (#/100ml)
IN0000175	Bethlehem Steel Corporation	May 1997-April 2002	3	167
INU060801	Burns Harbor and Bethlehem Steel	July 2000-April 2002	4	18
IN0000337	National Steel, Midwest Division	May 1997-October 2001	6	80

Table 4 suggests that the water quality of the discharges from the permitted facilities may not be contributors of bacteria to Little Calumet River or Burns Ditch. However, Bethlehem Steel Corporation and National Steel have had bypass events that could be contributing *E.coli* to the River. Bethlehem has had three reported overflow discharges between August 1998 and June 1999. Though the quality of this water is unknown, it is known that two of the overflows discharged 100,000 gallons of water. National Steel has had four reported events occurring between March and April 2000. However, these bypasses occurred in outfalls that are not required to sample for *E.coli*. National Steel has six outfalls that discharge to Burns Ditch, only one, outfall 006, is required to be sampled for *E.coli*.

Wastewater discharge for Wolverine Pipeline (ING080159) and Praxair, Inc. (IN0043435) do not have an established limit for bacteria. Instead, the permits have a chlorination requirement that is presumed to eliminate bacteria as a source of pollution to the receiving water.

2.2.2 Municipal Point Sources

Table 5 lists the permit limits for the municipal facilities from Table 2A.

TABLE 5
MUNICIPAL NPDES FACILITIES' PERMIT LIMITS

NPDES No.	Facility Name	Average Monthly E. coli (CFU/100 ml)	Daily Maximum E.coli (CFU/100 ml)	Daily Average Fecal Coliform (#/100 ml)	Daily Maximum Fecal Coliform (#/100 ml)
IN0024368	Portage Municipal STP	125	235	--	--
IN0022578 [a]	Chesterton Municipal STP	125	235	--	--

[a] Includes the discharge form the Town of Porter WWTP (INU046949)

Table 6 lists the characteristics of the reported discharge from these facilities based on their submitted discharge monitoring reports.

TABLE 6
MUNICIPAL NPDES FACILITIES' CHARACTERISTICS

NPDES No.	Reporting Dates	Ave. Monthly Conc. (CFU/100 ml)	Ave. Monthly Conc. (MTEC-MF)	Ave. Max. Wkly/Dly Conc. (CFU/100 ml)	Ave. Max. Wkly/Dly Conc. (MTEC-MF)	Ave. Monthly Conc. Fecal Coliform (#/100 ml)	Ave. Max. Wkly/Dly Conc. Fecal Coliform (#/100ml)
IN0024368[a]	May 1997-April 2002	9	7	52	112	--	--
IN0022578[b]	May 1997-April 2002	11	26	181	61	--	--

[a]*E.coli* values were recorded in MTEC-MF from May 1997 to June 2001 and CFU/100 ml from October 2001 to April 2002
[b]*E.coli* values were recorded in MTEC-MF from May 1997 to June 2001 and CFU/100 ml from July 2001 to April 2002

2.2.3 Chesterton Discharge Monitoring Report Analysis

By using the discharge monitoring reports for Chesterton from July 1998 to August 2000 an *E.coli* load was developed per day/per month. This value ranged from 0.001×10^{12} to 0.005×10^{12} CFU/day/month. Next a monthly per day load was determined just downstream of the wastewater treatment plant at ITF Site #212. This load represented the total load (point sources + nonpoint sources) in the stream on the eastern branch. These values ranged from 0.23×10^{12} to 0.68×10^{12} CFU/day/month. Subtracting the Chesterton load from this value gave the approximate load for the watershed upstream of the wastewater treatment plant, also considered the nonpoint sources. The Chesterton wastewater treatment plant load is minor in comparison to the watershed load, only approximately 0.5 percent to 1.0 percent of the total load.

2.3 Combined Sewer Overflows Contributing to the *E.coli* Impairment

The Town of Chesterton, the City of Hammond and the City of Gary have combined sewer overflows (CSOs) that discharge into the Little Calumet River. However only the CSOs from Chesterton and Gary discharge into segments that are impaired by *E.coli*. Therefore, CSOs from Hammond will not be addressed in this section.

CSOs typically occur when a rain event is large enough that the wastewater treatment plant cannot handle the total flow amount. However, CSOs also occur when there is equipment failure, as in the failure of a pump station. When these situations occur, some untreated wastewater along with stormwater runoff is diverted directly into the river. *E. coli* concentration in a CSO discharge varies depending on the extent by which it is diluted by stormwater runoff. Literature value of fecal concentration in CSO discharge ranges from 10^5 to 10^8 CFU/100mL (Novotny, 1981 and ASCE, 1992).

2.3.1 CSO for the Gary Sanitary District

The Gary Sanitary District (GSD) conducted sampling of the Little Calumet River to characterize and evaluate their CSO impact on the River (Water Quality Assessment Report 2002). The study monitored five rainfall events at six CSO outfalls and at 10 bridges in the Little Calumet (Figure 3). Two of the sample sites, B1 and B2, occur on Segment 23 of Little Calumet River. This segment is not impaired by *E.coli* and thus is not discussed in this section. Concentration of *E.coli* in the two wet weather events (Sept 2001 and April 2002) fell within the literature values (Figure 4).

Figure 5 shows the results of the GSD sampling at eight bridges during both the wet events and also three dry events. This graph indicates that even though the *E.coli* concentrations were high during the CSO events, there was another sampling day (June 25, 2001) that also had high concentrations, though not as high as during the CSO events.

2.3.2 CSO for the Town of Chesterton

The Town of Chesterton has a single CSO that combines with the effluent from their wastewater treatment plant through a single pipe, that discharges into Segment 22 of the Little Calumet River. Although Chesterton has not conducted a stream characterization report like Gary, they have recorded all occurrences of bypasses and also conducted periodic sampling of their outfall in coordination with the Interagency Task Force *E.coli* monitoring.

Figure 6 shows the bypasses that occurred between March 1998 and November 2000 along with the sampling that occurred at the wastewater treatment plant outfall (ITF Site #211). There are eleven occurrences where the *E.coli* measured was larger than the 235 CFU/100ml standard. However, none of these occurred when there was a CSO event. Only one sample coincided with a bypass occurrence, this occurred on June 14, 2000. A bypass of 757,000 gallons occurred and an *E.coli* concentration of 16 CFU/100ml was recorded.

It should also be noted that the Chesterton wastewater treatment plant is currently under going expansion to bring the facility up to 10 MGD (with an average design flow of 4.6 MGD) from it's current 2 MGD. It is expected that this expansion should be complete in the fall of 2003. Increasing the capacity of the plant should greatly reduce, if not eliminate, the occurrences of CSOs.

FIGURE 3
GARY SANITARY DISTRICT SAMPLE LOCATIONS

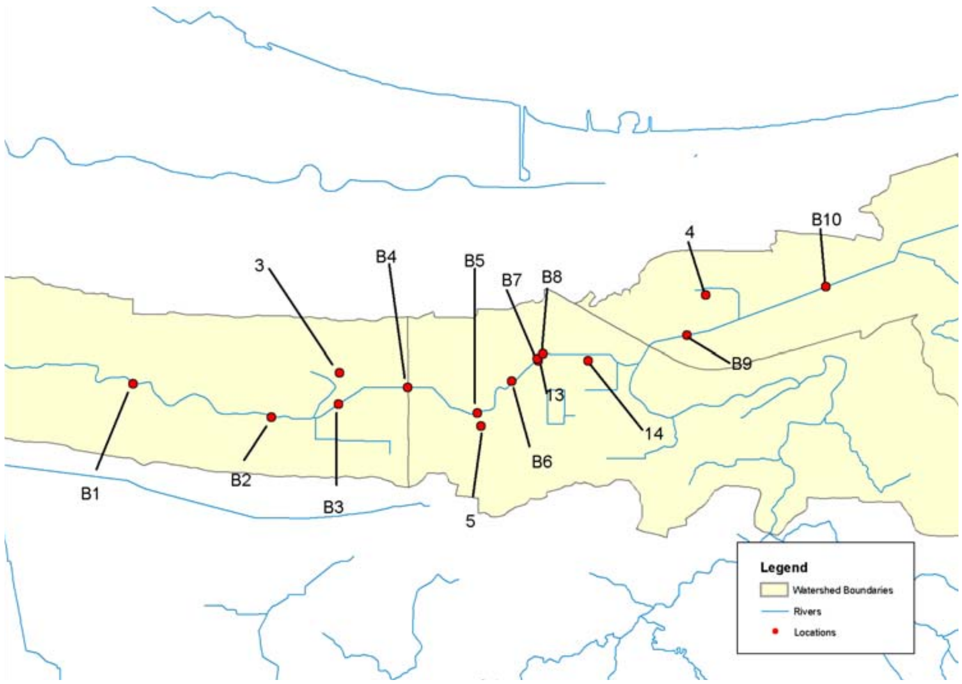


FIGURE 4
GSD CSO EVENT MONITORING

FIGURE 5
GSD BRIDGE SAMPLING FOR *E.COLI*

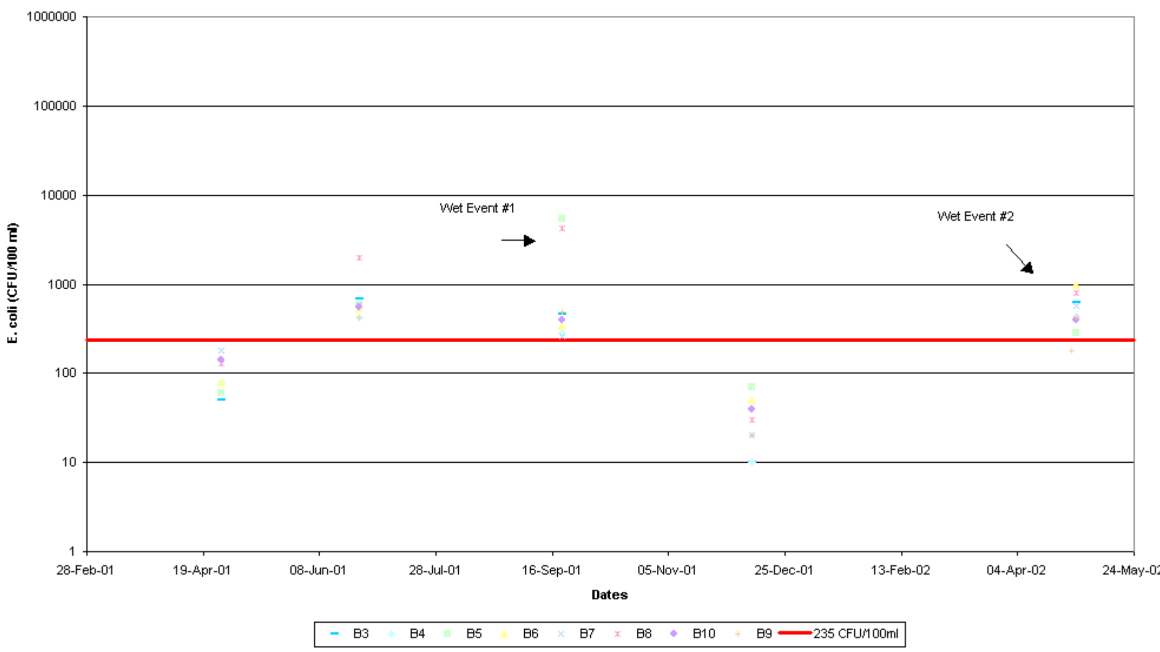
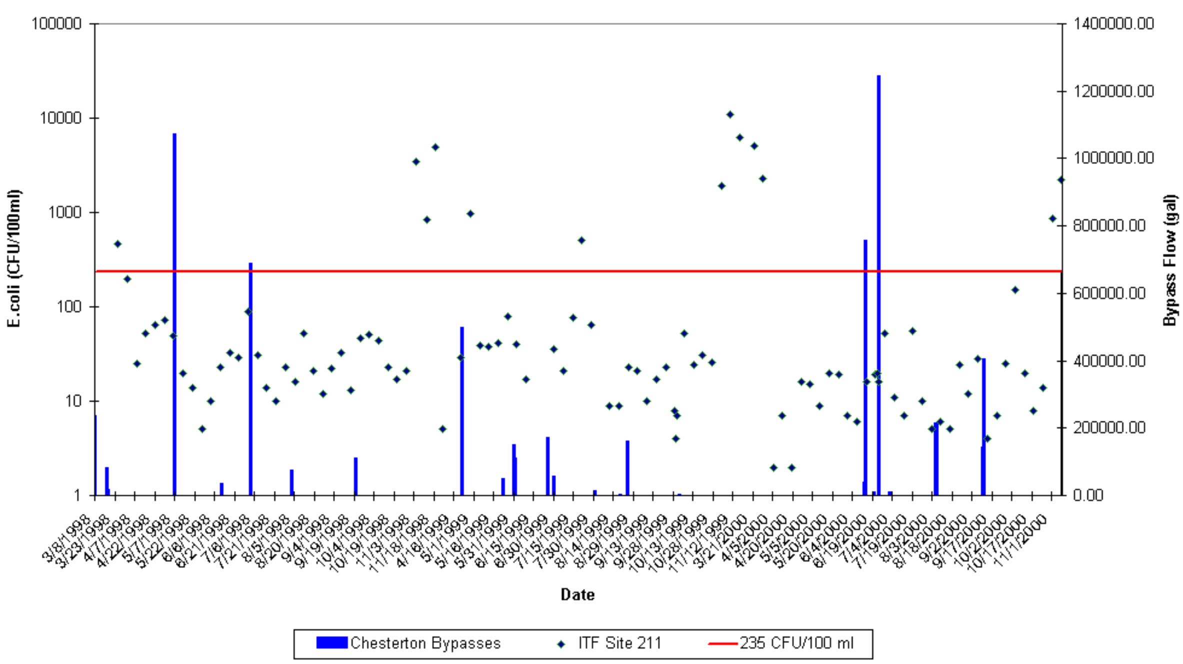


FIGURE 6
CHESTERTON BYPASSES COMPARED TO ITF SITE #211 (WWTP OUTFALL)



2.4 Point Sources Contributing to the Cyanide Impairment

There is only one NPDES facility, ING080159-Wolverine Pipeline Company, that discharges into segment 24 of the Little Calumet River. There are no facilities that discharge directly into segment 23 of the Little Calumet River. There is one facility, ING080131-Tranmontaigne Pipeline, that discharges into Plum Creek, which empties into Hart Ditch. Another facility, ING080166-Speedway Service Station #8338 discharges into a storm sewer that empties into Caddy Marsh Ditch, which empties into Hart Ditch. Hart Ditch is a tributary of Little Calumet River that joins the Little Calumet River just south of I-80 and west of US Hwy 41. None of these facilities are required to monitor for cyanide in their discharges.

There are two facilities, ING340034 and ING340026, which appear to discharge into Schererville Ditch, which is a tributary to Hart Ditch. However, based on their permits the discharge actually is discharged to Turkey Creek via ditches. Neither, report any cyanide in their monitoring reports.

Therefore, there are no known point source contributors of cyanide in the watershed for segments 23 and 24 of Little Calumet River.

2.4.1 Gary Combined Sewer Overflows Contributing to the Cyanide Impairment

The Cities of Gary and Hammond both have CSOs that discharge into Segments 23 and 24 of Little Calumet River. Stream sampling conducted as part of the GSD's Water Quality Assessment of the Little Calumet River identified only two samples that were above the detectable limit. However neither value was above the standard (Figure 7).

Figure 8 shows the results for the samples collected at the bridges. Bridges six and eight (B6 and B8) each had one sample that had values above the standard. Both of these occurred during dry weather. The two bridges are also located on Little Calumet River segment 24; no samples were above the detection limit for the bridges that are located in segment 23.

2.4.2 Hammond Combined Sewer Overflows Contributing to the Cyanide Impairment

The Sanitary District of Hammond (Hammond) also conducted a sampling program as part of their Water Quality Assessment report for the Little Calumet River in 1995. Hammond has nine CSO pump stations and outfalls along Little Calumet River and an additional seven gravity CSO outfalls on Schoon Ditch (tributary to Hart Ditch) in the Town of Munster. However, only four stations on Little Calumet River were sampled to represent the typical quality of all CSO discharge locations.

The detection limit for the analytical method for cyanide conducted by Hammond was 0.50 mg/L, well above the water quality standard. Of the three storm events that were sampled; (August 11th, October 8th, and October 31st.), there were no samples that detected cyanide. Therefore, the data provided by Hammond does not help to determine sources within the watershed.

FIGURE 7
GSD CSO SAMPLING FOR CYANIDE

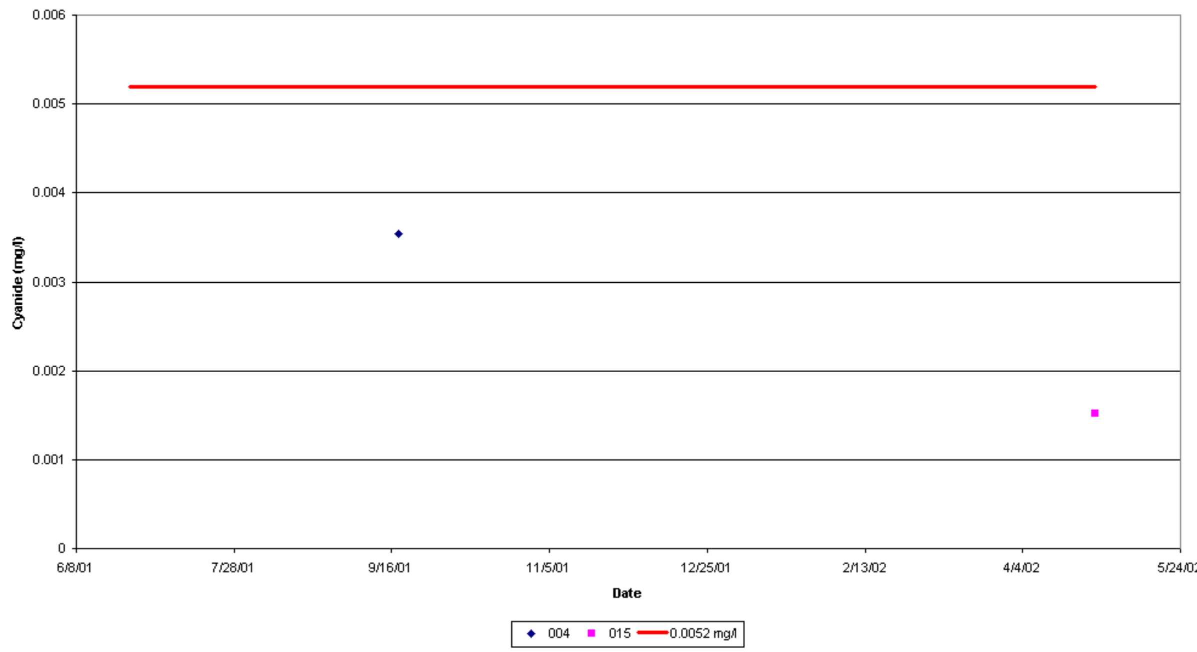


FIGURE 8
GSD BRIDGE SAMPLING FOR CYANIDE

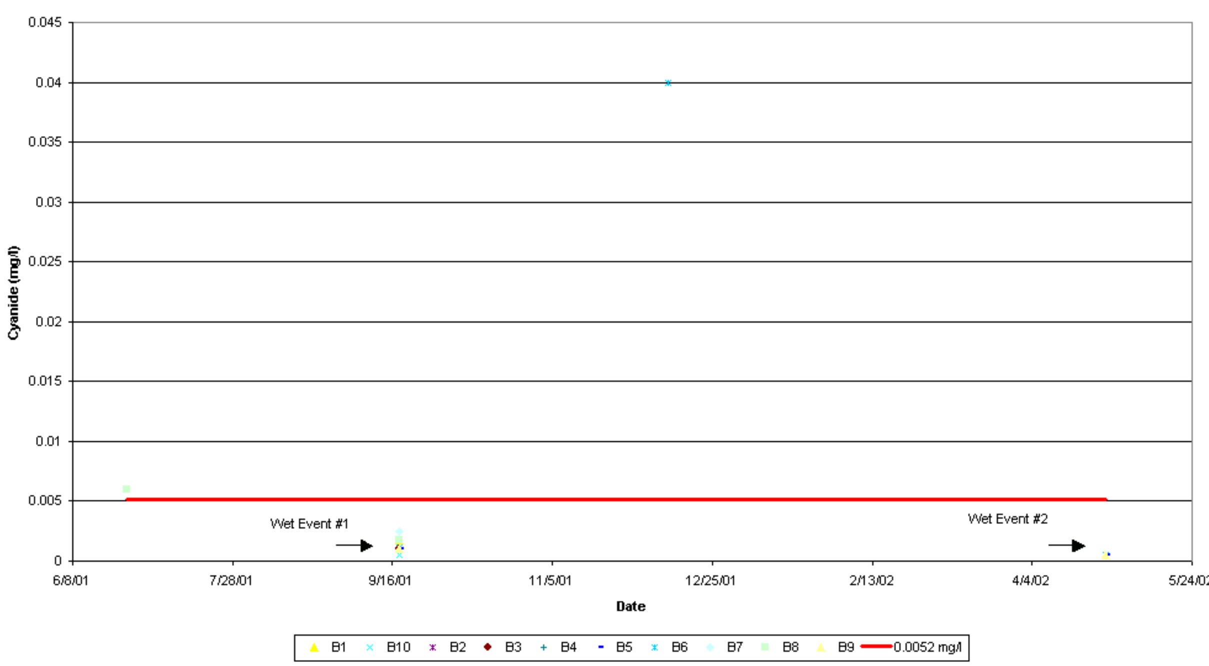
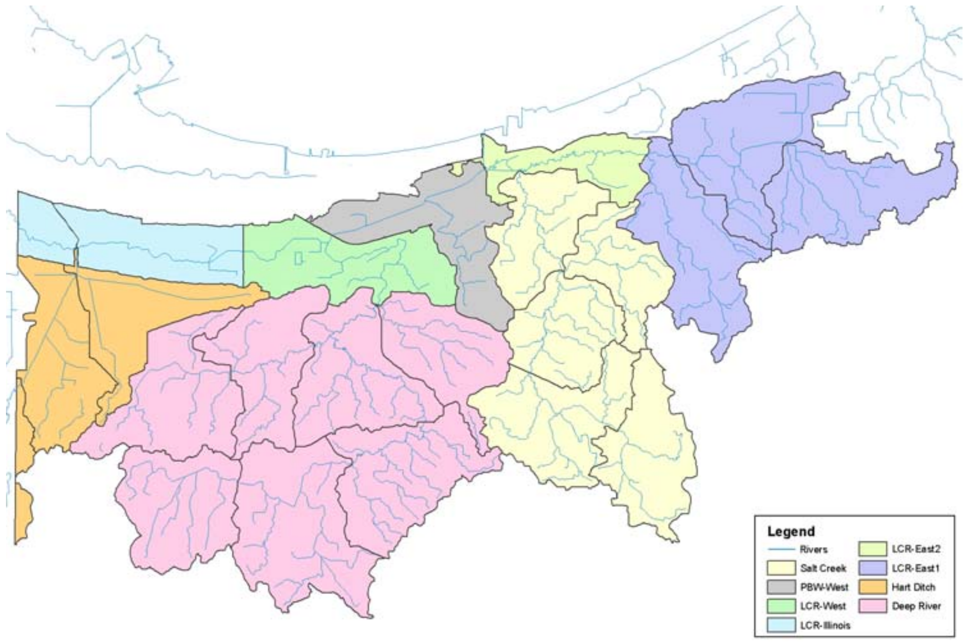


FIGURE 9
LITTLE CALUMET WATERSHED DRAINAGE BASINS



3. ASSESSMENT OF NONPOINT SOURCES

3.1 General Sources

Nonpoint source of pollution is separated into urban and rural components. In rural areas, sources of bacteria may include erosion of sediment, animal waste, runoff from concentrated areas of livestock, wildlife and failing septic systems. In urban and residential areas, the nonpoint source pollution is associated with impervious areas, leakage of sanitary sewers, and failing septic systems.

Cyanide impairment is mostly associated with point sources such as metal plating facilities and plastics manufacturing. However, there can be nonpoint source contributions of cyanide. Some of the nonpoint sources can be from improperly closed landfills, unknown/illegal dumping and groundwater inflow.

3.2 Land Uses Contributing to E.coli Impairment

There is a strong correlation between impervious area in a watershed and bacteria concentrations in the receiving stream (Tufford and Marchall, 2002). Tufford and Marchall observed that geometic mean concentration of fecal coliform bacteria from a mixed land use watershed ranged between 400 and 600 colonies/100 mL. Bannerman, et. al. (1991) sampled bacteria concentrations from various source areas (residential rooftops, industrial rooftops, residential streets, commercial parking lots, etc.) Bannerman found that runoff from urban residential areas contained greater concentrations of fecal bacteria than commercial and industrial areas. Residential streets contributed most of the bacteria, while parking lots and arterial streets were significant sources of bacteria in commercial and industrial areas. Bannerman sampling of pet feces in the Monroe Street drainage area suggested that domestic pets (dogs and cats) represented less than 15 percent of the total fecal coliform bacteria measured from the study area. Therefore, it was concluded that the distribution of bacteria was attributed more to the distribution of urban wildlife (birds, squirrels, raccoons, etc.) than domestic pets.

To better discuss the impact of land use in the Little Calumet watershed, the watershed was broken into six drainage basins: the Little Calumet River-East 1(LCR-East1), Little Calumet River-East 2 (LCR-East2), Little Calumet River West (LCR-West), Portage Burns Waterway-West (PBW-West), Salt Creek and Deep River (Figure 9). The watershed delineations were based on 14-digit USGS hydrologic unit areas.

Twenty land use classes were identified in the watershed. These were grouped into eight categories. Table 7 below lists the various categories along with the percentage of imperviousness for each category.

TABLE 7
LAND USE CATEGORIES

Land Use Categories	Pervious/Impervious (Percentage)	USGS Land Use Categories
Agriculture	Pervious (100%)	Cropland and Pasture Confined Feeding Ops Other Agricultural Land Orchards, Groves, Vineyards, Nurseries, or Ornamentals
Residential	Impervious (20 – 40%)	Residential
Forest	Pervious (100%)	Deciduous Forest Land Evergreen Forest Land Forested Wetland
Water	Pervious (100%)	Reservoirs Nonforested Wetland Lakes
Industrial	Impervious (60 – 80 %)	Industrial
Commercial	Impervious (75 - 95%)	Commercial and Services
Urban	Impervious (30 - 60%)	Mixed Urban or Built-up Other Urban or Built-up Transportation, communication, utilities Transitional areas
Other	Pervious (100%)	Strip Mines Sandy Areas (non-Beach) Nonclassified land uses

Table 8 shows the present land use distribution in each of the six drainage basins in the Little Calumet watershed.

TABLE 8
LAND USE DISTRIBUTIONS BY DRAINAGE BASIN

Land Use	Drainage Basins Within the Little Calumet Watershed											
	LCR-East1		LCR-East2		Salt Creek		PBW-West		LCR-West		Deep River	
	Drainage Area (mi^2)	Percent of Area	Drainage Area (mi^2)	Percent of Area	Drainage Area (mi^2)	Percent of Area	Drainage Area (mi^2)	Percent of Area	Drainage Area (mi^2)	Percent of Area	Drainage Area (mi^2)	Percent of Area
Agriculture	45.71	71.3%	3.12	29.2%	51.33	66.3%	8.43	43.1	5.79	29.6%	93.36	66.7%
Residential	1.02	1.6%	1.91	17.9%	8.33	10.8%	4.33	22.1	7.76	39.5%	17.15	12.3%
Forest	13.41	20.9%	2.49	23.3%	11.94	15.4%	2.38	12.2	1.89	9.7%	14.52	10.3%
Water	1.06	1.7%	0.31	2.8%	0.72	0.9%	0.85	4.4	0.26	1.4%	2.29	1.6%
Industrial	0.00	0.00%	0.77	7.2%	0.05	0.1%	0.00	0.00	0.00	0.00%	0.36	0.3%
Commercial	0.67	1.0%	0.50	4.7%	2.62	3.4%	1.68	8.6	1.95	9.9%	6.50	4.7%
Urban	2.21	3.5%	1.51	14.1%	1.92	2.5%	1.53	7.8	1.93	9.9%	5.07	3.6%
Other	0.00	0.00%	0.09	0.8%	0.54	0.7%	0.36	1.8	0.00	0.00%	0.64	0.5%
Total	64.08	100%	10.7	100%	77.45	100%	19.56	100%	19.58	100%	139.89	100%

3.3 Failing Septic Systems Contribution of *E.coli*

Septic system failure creates the potential of *E.coli* entering water bodies due to incomplete treatment of the waste. No county specific information was available for failure rates of septic system in the Little Calumet watershed. However, literature reports the failure rates to be between 2.5 percent and 18 percent (Johnson and Tuomari, 1998). Horsley and Whitten (1996) estimated an average daily effluent discharge of 70 gallons/capita/day and a concentration of fecal bacterial of 10^4 counts/100 mL.

3.4 Wildlife Sources of *E.coli*

Previous TMDLs estimated bacteria loadings attributed to wildlife by using a single wildlife species, such as the white tail deer, to represent the total load to the watershed (Table 9).

TABLE 9
BACTERIA LOADING RATES FROM WILDLIFE
FROM PREVIOUS INVESTIGATIONS

Study and State	Animal	Assumed Animal Density	Assumed Daily Loading Rate for Fecal Coliform
Muddy Creek TMDL, VA 1999	Deer	35/mi^2	0.5 x 10^9 count/animal/day
Crooked Creek TMDL, AL 2001	Deer	45/mi^2	0.5 x 10^9 count/animal/day
Duck Creek TMDL, AK 2000	Ducks Dogs	50/WATERSHED 1,250/watershed	2.43 x 10^9 count/animal/day 5 x 10^9 count/animal/day
Norfolk Wildlife Centre, Yarmouth, UK 2001	Rabbits	NA	NA

Estimates of the loading rates for other wildlife species are summarized in Table 10. Estimating annual loads to the Little Calumet River from wildlife will require an estimate of animals in the watershed and in some cases an estimate of daily amount of waste each animal produces. All literature sources report fecal coliform counts and not *E.coli*. Therefore, an estimate of the *E.coli* produced will have to be based on a percentage of fecal coliforms. Several researchers have established correlations between fecal coliforms and *E. coli* bacteria (LTI, 1999 and Chapman, 2001).

TABLE 10
BACTERIA LOADING RATES FROM VARIOUS WILDLIFE SPECIES

Source	Animal	Assumed Daily Loading Rate for Fecal Coliform	Units
Crane (1983)	Field Mouse	3.3 x 10^5	counts/g
"	Rabbit	20	counts/g
"	Chipmunk	1.48 x 10^5	counts/g
"	Rat	1.8 x 10^5	counts/g
"	Robin	0.25 x 10^5	counts/g
"	English Sparrow	0.25 x 10^5	counts/g

Source	Animal	Assumed Daily Loading Rate for Fecal Coliform	Units
"	Starling	0.1×10^5	counts/g
"	Blackbird	0.09×10^5	counts/g
"	Pigeon	0.1×10^5	counts/g
Fleming (2001)	Goose	1.53×10^4	count/g
ASAE (1998)	Duck	2.43×10^9	count/animal/day
Arnold (2003)	Deer	5.0×10^{10}	count/animal/day
"	Beaver	2.5×10^8	count/animal/day
"	Raccoon	1.25×10^8	count/animal/day

3.5 Agricultural Sources of *E.coli*

Discussions with Bill Moran in the Lake County NRCS office and Chuck Walker in the Porter County NRCS office indicated that there is very little livestock in the Little Calumet watershed. Therefore, estimates of loads from this source will likely be lumped in with the estimate of loads from wildlife. Bacteria production for livestock that has been reported in the literature is summarized in Table 11.

TABLE 11
BACTERIA LOADING RATES FROM VARIOUS LIVESTOCK (ASAE, 1998)

Animal	Assumed Daily Loading Rate for Fecal Coliform	Units
Dairy Cow	1.01×10^{11}	count/animal/day
Beef Cow	1.04×10^{11}	count/animal/day
Hog/Swine	1.08×10^{10}	count/animal/day
Sheep	1.2×10^{10}	count/animal/day
Horse	4.2×10^8	count/animal/day
Chicken	1.36×10^8	count/animal/day
Turkey	9.3×10^7	count/animal/day
Dogs	4.09×10^9	count/animal/day

3.6 Land Use Contributing to Cyanide Impairment

Stormwater is one possible source of cyanide that is found in the Little Calumet River. However, there appears to be no sampling of the stormwater in the watershed for cyanide. Cyanide has been found in the monitoring of stormwater in other watersheds. Concentrations are typically low, in the range of 5.0 µg/L from residential areas and 6 to 11 µg/L from commercial/industrial lands (DEQ 2001, Pitt, et al. 2003). Bannerman (1992, 1993), monitoring of stormwater in Milwaukee and Madison, Wisconsin, detected cyanide in 12 percent of the samples. These are similar results reported by the Alabama Department of Environmental Management in their 2000 study that characterized pollutants in stormwater runoff from five different catchments areas in Dothan, Alabama. They reported cyanide concentrations in the range of 1 to 51 µg/L in only 6 out of the 46 (13%) samples at the five sites.

3.7 Cyanide from Deicers

Large amounts of deicing material are applied annually to the interstate system that runs almost the entire length of the watershed. Cyanide compounds, such as Sodium ferrocyanide and ferric ferrocyanide, are essential additives to rock salt as an anti-caking agent. They have been in use since the 1950s (Paschka et al. 1999). The quantity of cyanide in road salt is small (usually 0.01% by dry weight). In a study by Sansalone and Glenn (2000), discharge from an interstate on which 216,000 kg of rock salt had been applied of approximately was found to contain 6 kg of cyanide. Initial studies have shown that road salt releases iron cyanide into nearby waterways. This form of cyanide is non-toxic (Mangold, 2000). Exposure to sunlight transforms these iron cyanide compounds into free cyanide (HCN), which is toxic to aquatic life and humans (Novotny et al. 1999). Some of this free cyanide becomes gaseous and volatilizes into the atmosphere. There is insufficient research to know how much of it volatizes (Novotny et al., 1999 and Paschka et al. 1999). In the dissolved, aqueous form of free cyanide level could become toxic to aquatic life. Formation of free cyanide is less likely to occur in deep, turbid, shady stream reaches which lack sunlight.

3.8 Legacy Impairments for Cyanide

The Little Calumet River is in the Eastern Lake Section of the Central Lowland physiographic province. Surface deposits consist primarily of glacial and lacustrine sand, silt and clay. It is generally flat and was originally characterized by dunes beach ridges, morainal islands and bedrock mounds. The Little Calumet River was originally surrounded by extensive wetlands.

The USGS conducted an inventory of fill deposits in the Little Calumet River watershed and northwest Indiana (WRI Report 96-4126). They were able to show that as the watershed developed, low areas and wetlands were filled with a variety of industrial wastes, municipal solid wastes, steel-industrial wastes, construction debris, ash, cinders and dredge materials. Most of the fill identified by the USGS was along the Lake Michigan shoreline and the Grand Calumet watershed. Smaller deposits were identified in the Little Calumet watershed. Fill deposited prior to 1964 was placed with no environmental safeguards. These materials can be associated with cyanide, metals, volatile and semi volatile organics. Fill deposits along the Little Calumet River were found to reach the depth of 20-feet.

These deposits may be a possible source of the cyanide that is observed in the Little Calumet River. There are possibly two transport mechanisms in place. First, groundwater may be leaching cyanide from the fill deposits into the Little Calumet River, especially if the deposits were steel-industry wastes, ash or cinders. The second possible mechanism is through surface runoff that washes over filled areas and picks up cyanide in that process. There is insufficient data to isolate the role each mechanism(s) plays in delivery of the cyanide to the river system.

3.9 Forms of Cyanide

There are three forms of cyanide that IDEM uses in their sampling: total, free, and chlorine amenable. Total cyanide is a measure of all forms of cyanide, whereas free cyanide is a measure of only the forms of cyanide that are "available" to be lost from the system. Chlorine amenable cyanide is another type of cyanide that is sometimes used in water quality sampling.

Even though the state standard for cyanide is written for free cyanide (0.0052 mg/L), total cyanide measurements have been used by IDEM because it provides a margin of safety when considering toxicity. If high values of total cyanide are detected, then the sample is usually also analyzed for free cyanide. In some cases the sample is also tested for chlorine amenable cyanide. However, this requires that two tests be administered which could create errors in the results.

4. DATA ANALYSIS

4.1 Hydrologic Characterization

Understanding the potential causes of water quality characteristics of the data gathered in the Little Calumet River Watershed requires an understanding of the hydrology of the system. A given concentrations of a pollutant at low flows represents lower level of pollutant loadings than the same concentration at a higher flow condition. Therefore, knowing the flow conditions at the time that a sample is taken becomes an important piece of information in determining the source of pollution. Of the over 80 sampling sites in the system, streamflow was measured at only three (05536195- Little Calumet River at Munster, 04093500- Burns Ditch at Gary and 40940000- Little Calumet River at Porter).

There are eight key stream gages in the watershed (Table 12). Five of the eight stream gages are currently active. Flow records of various combinations of gages were plotted against each other to indicate the level of homogeneity of the watershed to runoff events and the interrelationships of flows. Figure 10 is an example of that analysis. The high correlation between some gages will be used to create a synthetic streamflow record for gages and locations that are missing data. From this analysis there are several significant observations:

- Observed flows in the Little Calumet River at Munster (05536195) are primarily (around 90%) from Hart Ditch.
- The majority, approximately 70 percent, of the flows in Burns Ditch comes from Deep River.
- Flow characteristics of Salt Creek and the East Branch of the Little Calumet River are nearly identical (R^2 = 87%).
- Flows in Burns Ditch at Portage (04095090) are generally made up of 20 percent from the East Branch of the Little Calumet River, 20 percent from Salt Creek and 30 percent from Burn Ditch at Gary (04093500) and the remaining 30 percent from the adjacent drainage areas. Of the 30 percent from the drainage areas, Bethlehem Steel is a major source. This facility contributes, 100 MGD (average) of flow to the East Branch of Little Calumet River. At low flows, the facility is a major dilution source to the River.
- The discharge characteristics of the "upper watersheds" (Hart Ditch, Deep River, Salt Creek and the East Branch of the Little Calumet River) are very similar.

TABLE 12
CORRELATION COEFFICIENT BETWEEN SETS OF USGS STREAM GAGES

Station ID	Description	Data Range	Little Calumet River at Munster	Hart Ditch at Munster	Deep River at Lake George outlet at Hobart	Little Calumet River at Gary	Burns Ditch at Gary	Salt Creek near McCool	Little Calumet River at Porter	Burns Ditch at Portage
05536195	Little Calumet River at Munster	7/1958 - present								
05536190	Hart Ditch at Munster	10/1942 - present	73%							
04093000	Deep River at Lake George outlet at Hobart	4/1947 - present		67%						
04093200	Little Calumet River at Gary	7/1958 – 11/1987 Stage only since 12/1984	54%	35%	59%					
04093500	Burns Ditch at Gary	10/1943 – 9/1991			94%	74%				
04094500	Salt Creek near McCool	10/1945 – 9/1991		72%	80%					
04094000	Little Calumet River at Porter	10/1945 – present		62%	0%		53%	87%		
04095090	Burns Ditch at Portage	10/1994 - present			56%		58%	67%	67%	

4.2 Characterizing Pollutant Loads

4.2.1 Approach

A simplified two-part approach was taken to further characterize the significance of various pollutant sources. The first involved a simple comparison of the numeric average *E.coli* concentrations for each of the monitoring sites. The second follows the same methodology developed by the Kansas Department of Health and Environment (2001) for the development of bacteria TMDLs. This was necessary to guide the selection of the appropriate analytical approach and analytical tool (computer model) for developing the TMDLs.

4.2.2 Assessment of Water Quality Monitoring

Tables 13 through 17 summarize the monitoring data reported in the study area. The tables are organized by the sponsoring agency and are crossed referenced to the monitoring programs that may be sharing the same site. This assessment summarizes the numeric average and the minimum maximum reported *E.coli* concentrations. Figure 11 is a schematic of the average observed *E.coli* concentrations from the major hydrologic components of the system.

FIGURE 10
EXAMPLE: PLOT OF FLOWS OF HART DITCH AND LITTLE CALUMET RIVER

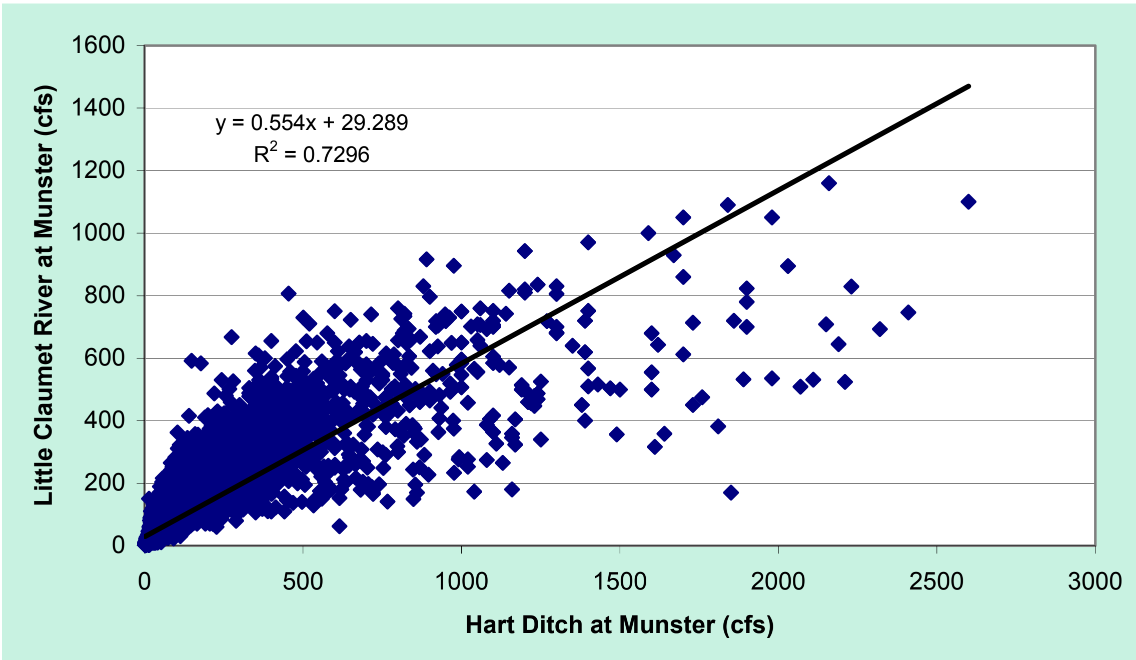
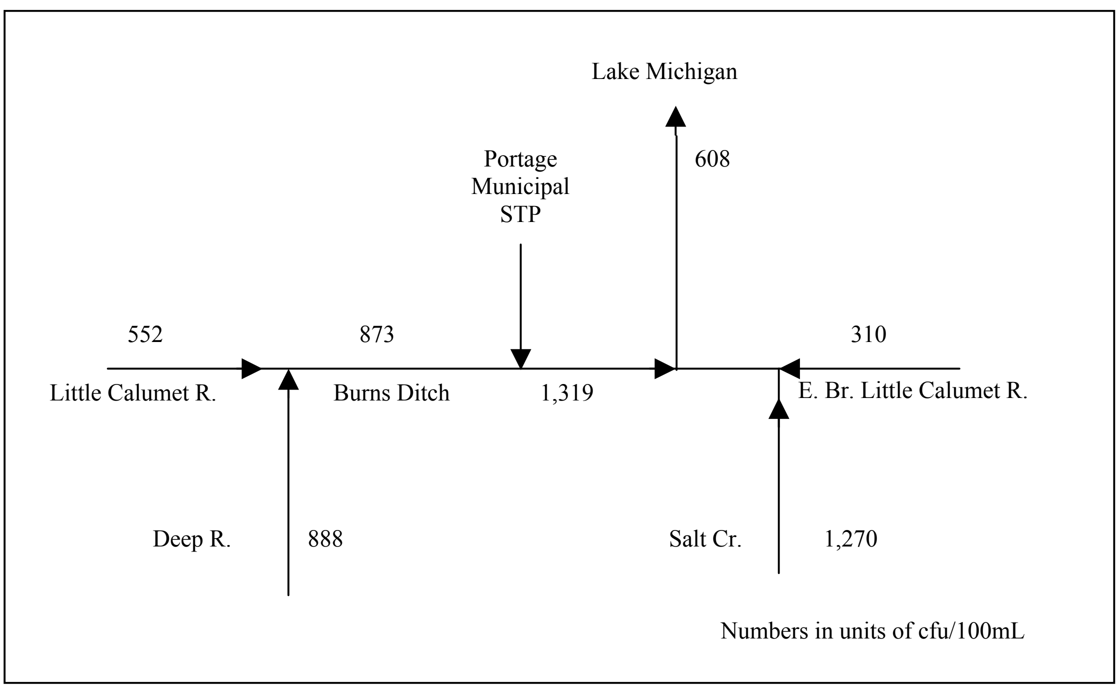


FIGURE 11
SCHEMATIC OF AVERAGE E.COLI CONCENTRATIONS,
LITTLE CALUMET-BURNS DITCH WATERSHED



This data suggests that Salt Creek and Deep River are major sources of *E.coli*. This may possibly be due to point sources in their respective watersheds. The Portage Municipal Sewage Treatment Plan appears to be a major source as well, according to the data from LMG040-003 (BD-3W) and ITF #220. However, this is not consistent with reported *E.coli* concentrations in the facilities discharge monitoring reports (Table 6). Further analysis will be needed to determine if the increase in *E.coli* is associated with the treatment plant, another unidentified point source, or urban stormwater runoff. It also appears that the concentration of *E.coli* between rainfall events (dry weather flows) is running around 300 to 600 cfu/100mL, consistently above the State's water quality standard.

TABLE 13
IDEM MONITORING SITES

Monitoring Station	Shared Sites	Number of Samples	Numeric Average (cfu/100mL)	Minimum (cfu/100mL)	Maximum (cfu/100mL)
LMG040-0003	BD-3W	9	891.6	38.0	5,200.0
LMG040-0004		5	567.1	9.7	1,413.6
LMG060-0002		116	711.1	17.0	12,200.0
LMG060-0005	BD-2E	114	458.5	5.0	5,500.0
LMG060-0006	BD-0	113	608.3	0.0	18,800.0
LMG060-0007		113	687.9	10.0	4,000.0
LMG060-0008		114	840.1	5.0	9,700.0
LMG060-0009		5	207.5	49.6	461.1
LMG060-0011		4	708.2	517.2	920.8
LMG060-0012		5	250.0	40.0	900.0
LMG060-0013		1	310.0	310.0	310.0
LMG060-0014		5	107.5	10.0	330.0
LMG060-0015	LCR-39	5	492.0	120.0	920.0
LMG060-0016		5	428.0	130.0	840.0
LMG060-0017	212	46	442.6	50.0	2,200.0
LMG060-0019		5	366.0	100.0	820.0
LMG060-0020	208.5	78	722.2	60.0	6,200.0
LMG060-0021		5	418.0	200.0	1,100.0
LMG060-0022		5	180.0	130.0	230.0
LMG060-0025		5	430.6	209.8	648.8
UMC030-0004	LCR-13	48	6,465.2	50.0	86,000.0
UMC030-0005		5	4,763.1	1,413.6	8,164.0
UMC030-0007		5	2,861.1	770.1	5,475.0
LMG040-0003	BD-3W	9	891.6	38.0	5,200.0

TABLE 14
INTERAGENCY TASK FORCE (ITF) MONITORING SITES

Monitoring Station	Shared Sites	Number of Samples	Numeric Average (CFU/100Ml)	Minimum (CFU/100mL)	Maximum (CFU/100mL)
208.5	LMG060-0020	78	722.2	60.0	6,200.0
209		111	689.3	20.0	10,600.0
210		41	394.7	22.0	2,800.0
211		110	435.2	2.0	10,800.0
212	LMG060-0017	46	442.6	50.0	2,200.0
213	LMG060-0002	116	711.1	17.0	12,200.0
214		61	29.4	0.0	300.0
215		65	275.5	0.0	4,000.0
216	B9	92	551.8	0.0	8,200.0
217		44	1,360.3	1.0	3,000.0
218		41	1,457.2	10.0	3,000.0
219		41	888.0	1.0	3,000.0
220		105	873.7	0.0	83,000.0
220.1		29	1,747.8	23.0	34,400.0
221		102	1,319.1	27.0	23,000.0
222		41	752.4	3.0	14,800.0
223	BD-1	113	918.8	1.0	20,700.0
224		101	3.4	0.0	42.0
225	LMG060-0006 and BD-0	113	608.3	0.0	18,800.0
228		41	35.5	10.0	175.0
235		30	807.2	22.0	11,900.0

TABLE 15
IDEM FIXED MONITORING STATIONS

Monitoring Station	Shared Sites	Number of Samples	Numeric Average (CFU/100Ml)	Minimum (CFU/100mL)	Maximum (CFU/100mL)
BD-0	LMG060-0006 and 225	113	608.3	0.0	18,800.0
BD-1	223	113	918.8	1.0	20,700.0
BD-2E	LMG060-0005	114	458.5	5.0	5,500.0
BD-3W	LMG040-0003	9	891.6	38.0	5,200.0
LCR-13	UMC030-0004	48	6,465.2	50.0	86,000.0
LCR-39	LMG060-0015	5	492.0	120.0	920.0

TABLE 16
NONPOINT SOURCE MONITORING STATIONS

Monitoring Station	Shared Sites	Number of Samples	Numeric Average (CFU/100mL)	Minimum (CFU/100mL)	Maximum (CFU/100mL)
LAKE10		13	619.4	158.5	2,419.2
LAKE11		7	273.7	30.1	1,299.7
LAKE12		7	1,141.6	214.3	2,419.2
LAKE13		7	803.1	30.3	2,419.2
LAKE18		12	1,319.0	547.2	2,419.2
LaPorte21		9	235.7	0.0	1,201.0
LaPorte26		10	149.9	37.6	509.9
LaPorte27		16	563.7	24.9	1,986.3
LaPorte31		17	299.4	29.5	866.4
Porter09		8	1,153.8	410.6	2,700.0
Porter10		7	268.8	67.2	500.0
Porter11		8	1,868.3	248.1	5,000.0
Porter12		11	660.0	100.0	1,200.0
PORTER19		7	145.2	12.7	260.2
Porter20		2	382.4	135.4	629.4
Porter21		9	1,428.6	77.3	3,873.0
Porter22		9	332.1	37.9	913.9
Porter23		15	566.5	260.2	1,274.0
PORTER3		5	1,337.7	816.4	2,419.2

TABLE 17
GARY SANITARY DISTRICT MONITORING STATIONS

Monitoring Station	Shared Sites	Number of Samples	Numeric Average (CFU/100mL)	Minimum (CFU/100mL)	Maximum (CFU/100mL)
003		1	49,368.0	49,368.0	49,368.0
004		2	436,347.5	409,878.0	462,817.0
005		2	329,388.0	36,205.0	622,571.0
013		2	558,551.5	547,893.0	569,210.0
014		1	673,571.0	673,571.0	673,571.0
015		2	399,742.5	99,345.0	700,140.0
B1		5	705.2	20.0	1,400.0
B10		5	307.2	40.0	560.0
B2		5	278.4	10.0	609.0
B3		5	364.6	10.0	680.0
B4		5	247.0	10.0	439.0
B5		5	1,277.2	60.0	5,389.0
B6		5	401.4	50.0	1,000.0
B7		5	325.4	20.0	590.0
B8		5	1,443.8	30.0	4,273.0
B9	216	92	551.8	0.0	8,200.0

4.2.3 Kansas TMDL Curve Methodology

The Kansas Department of Health and Environment developed a simple method using historic flow records to conduct an initial evaluation of bacteria impairment sources. There are three steps to the Methodology developed. The first is to develop a flow-duration curve for the monitoring site. A flow-duration curve is the cumulative frequency of the historical daily flows. It represents the frequency that a given flow is exceeded. The second step is to multiply each of the daily flows by the water quality standard to create a daily load-duration curve. This is a "reference line" of the allowable average daily loads (cfus/day) for any given flow that would result in in-stream water quality just meeting the water quality standard of 235 CFU/100ml. Lastly, the observed pollutant concentrations are multiplied by the measured flow for that day. The "observed daily loads" are plotted on the same graph as the load-duration curve. Like the flow-duration curve, the load duration curve represents the frequency that water quality standards are or are not being met. Observed daily loads are compared to the "reference line". The difference between the observed daily load to the "reference line" indicates the reduction in pollution required to meet water quality standard, if the observed daily load is greater than the reference daily load. However if the daily load is below the reference daily load, the difference represents the additional pollutant load that the system can assimilate and still meet water quality standards.

Advantage of this approach

One of the challenges faced in interpreting water quality data is that different loading mechanisms tend to dominate different flow regimes. This approach helps to distinguish whether pollutant loads are from point sources or nonpoint sources. Loads that plot above the curve and in the region of exceedance of between 85 and 100 percent of days indicate a steady-input source, which often translates into the indication that the exceedance is the result of a point source. Loads that plot in the region between 10 and 70 percent suggest the presence of storm-driven source contributions (Stiles, 1999), typically nonpoint sources of pollution. A combination of both storm-driven and steady-input sources occurs in the transition zone between 70 and 85 percent.

Load duration curves

Load-duration curves were developed for a number of the key water quality stations. Streamflows were based on the nearest USGS gaging station. Streamflows were adjusted to the location of the water quality station of interest based on a ratio of the drainage areas. Streamflow for discontinued USGS gaging stations were estimated based on correlations with other gaging stations.

General Observation of Bacteria Loads

The general pattern of the load duration curves is fairly consistent from site to site. The majority of the observed water quality samples were taken during low flow (base-flow) conditions. Observed loads fell both above and below the reference line. As flows increased as a result of rainfall events daily pollutant loads consistently violated water quality standards.

General Observation of Cyanide Loads

The general pattern of the load duration curves is fairly consistent from site to site. The majority of the observed water quality samples were taken during low flow (base-flow) conditions. However, daily pollutant loads consistently violated water quality standards, regardless of streamflow.

4.3 East Branch Little Calumet River (Segments 21 &22)

The flow duration curve for the East Branch of Little Calumet River was determined at the USGS gage at Porter (040940000). The curve was developed using data from the period of record at the site (1945-2001). There are four sample locations that are near the gage that were used to determine the load duration curves: LMG060-0002 (#213), LMG060-0017 (#212), ITF #211, and ITF #210.

4.3.1 LMG060-0002 (ITF #213) Load Duration Analysis

LMG060-0002 is an IDEM station located at Wagner Road in Porter County. The Interagency Taskforce (ITF) has also collected samples (ITF #213) at this site. Samples from both sources were used to determine the load duration curve. This sample site is located upstream of the Porter streamflow gage. Streamflow at the sample site was determined based on the ratio of the drainage area at the Porter Gage (66.2 mi^2) and the drainage area at LMG060-0002 (65.4 mi^2). Most of the samples exceed the State's standard for maximum daily concentration (Figure 12). Many of the values occur when flows in the river were low, which normally, suggests the source of pollution is a point source. The Chesterton Municipal Sewage Treatment Plant, located upstream of the site, was initially thought to be contributing to the impairment. However, the monitoring of the bacteria concentrations coming from the plant suggests that it may contribute, it does not have a significant role in the impairment. The average *E.coli* concentrations are fairly consistent in this part of the watershed, ranging on average from 300 to 600 cfu/100mL. In addition, Figure 12 suggests that loads trend up as flows increase. These last two observations are indicative of a nonpoint source of pollution.

4.3.2 LMG060-0017 (ITF #212) Load Duration Analysis

LMG060-0017 is an IDEM station that is located at Waverly Road in Porter County, downstream of the Chesterton Sewage Treatment Plant (this site is also ITF #212). It is a very short distance upstream of LMG060-0002 (ITF #213). All samples were used to determine the load duration curve. The flows from the USGS gage at Porter (66.2 mi^2) were adjusted for the differences in drainage area. The load duration curve (Figure 13) is similar to Figure 12. Most of the samples plot above the curve and along the right side of the graph. Again, this implies that the cause could be a point source or a chronic impairment, but the trend of loads increasing with flows points more in the direction of a nonpoint source.

4.3.3 ITF #211 Load Duration Analysis

ITF site #211 is located at the Chesterton Municipal Sewage Treatment Plant Outfall. The flows were again adjusted for the difference in drainage areas (64.8mi^2) to create the load-duration curve in Figure 14. This figure shows that most of the samples did not exceed the *E.coli* standard. By looking at the dates of the samples that exceed the standard it was seen that all but one of the samples occurred between November and April when chlorination is not required. The other sample occurred during July of 1999 during a rain event of 0.30 inches. However, Chesterton recorded no CSO activity. By looking at this plot, it is shown that the Chesterton Sewage Treatment Plant probably has a small effect on the overall contribution of *E.coli* to the stream, and may be temporarily diluting the concentrations of bacteria in the stream.

4.3.4 ITF #210 Load Duration Analysis

ITF site #210 is located at Calumet Road, upstream of the Sewage Treatment Plant (48.3 mi^2 drainage area). The load-duration curve in Figure 15 has a similar pattern as Figures 12 – 14. This reinforces the theory that the treatment plant does not have a major effect on the *E.coli* loads in Little Calumet River. Instead, the loads are most likely coming from the nonpoint sources in the watershed.

4.4 Portage Burns Waterway (Segment 2)

The flow duration curve for the Portage Burns Waterway was determined at the USGS gage at Portage (04095090). The curve was developed using data from the period of record at the site (1994-2001). There are five sample locations that are near the gage that were used to determine the load duration curves: LMG060-0006 (ITF #225), ITF #224, LMG060-0012, BD-1 (ITF #223), LMG060-0007 and ITF #222 (ITF #235). Only LMG060-0006 is located at the gage location. However, a correction factor for drainage area was not used for the rest of the sample locations due to the small change in watershed area among the sites.

4.4.1 LMG060-0006 (ITF #225) Load Duration Analysis

LMG060-0006 is an IDEM station located at the Midwest Steel catwalk just upstream from the mouth in Porter County. Also at this location the Interagency Taskforce (ITF) has collected samples (ITF #225). All samples were used to determine the load duration curve. Looking at Figure 16, the load duration curve can be seen. It is seen that there is a fairly even distribution above and below the reference line indicating the allowable maximum daily load. This indicates that the *E.coli* impairment at the mouth of the River is a mixture of both point and nonpoint sources.

FIGURE 12
LOAD DURATION CURVE FOR LMG060-0002 (ITF SITE #213)

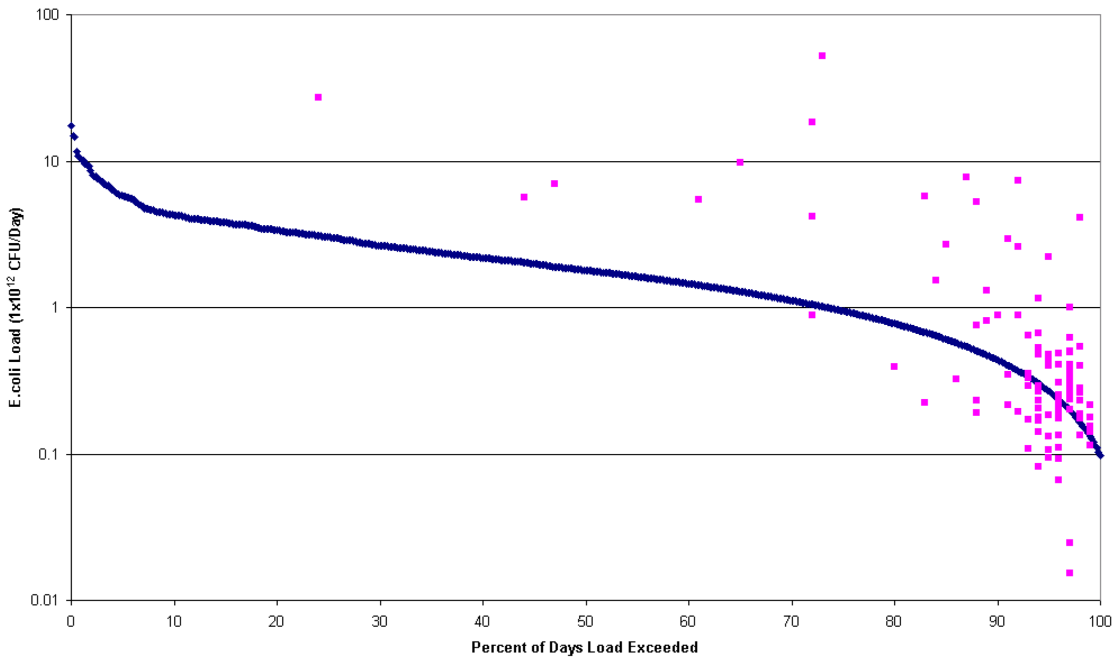


FIGURE 13
LOAD DURATION CURVE FOR LMG060-0017 (ITF SITE #212)

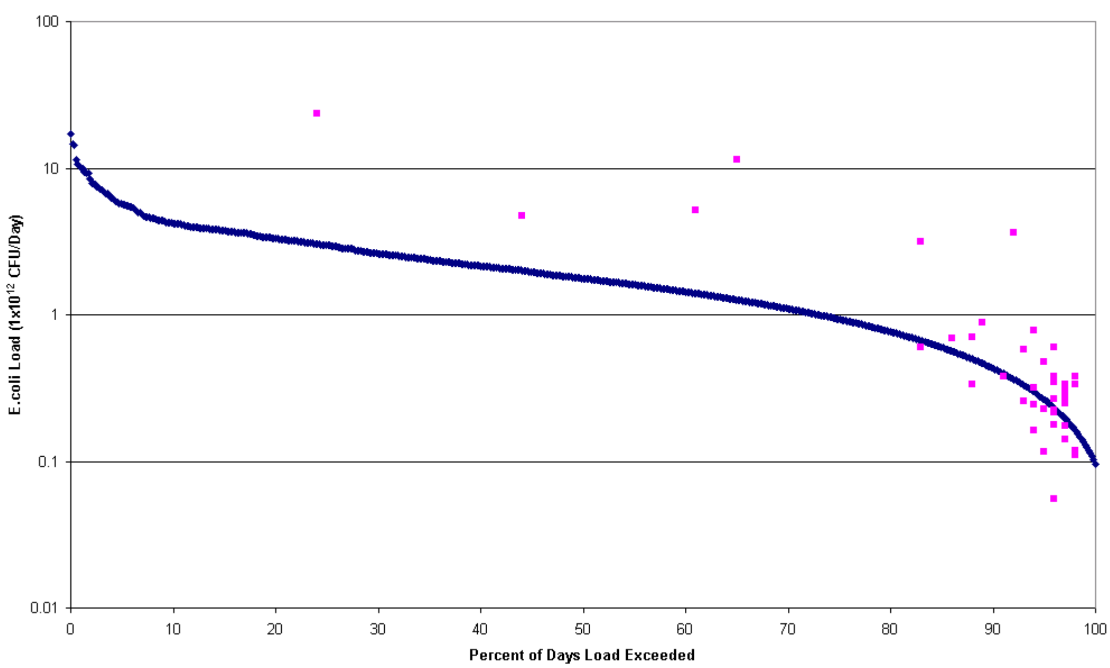


FIGURE 14
LOAD DURATION CURVE FOR ITF SITE #211

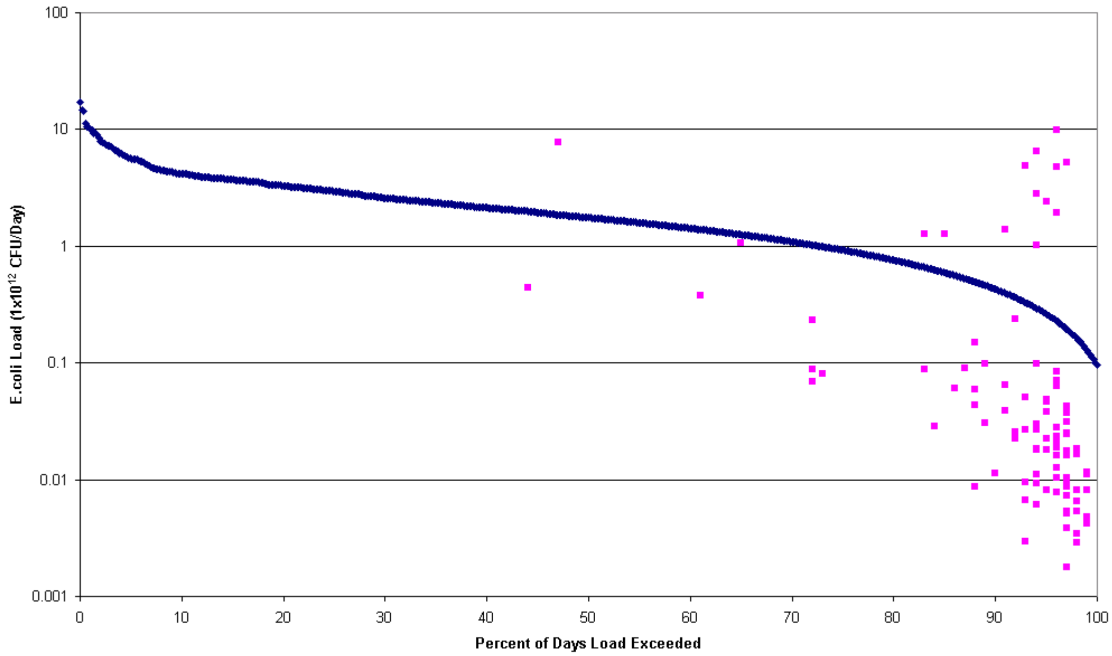
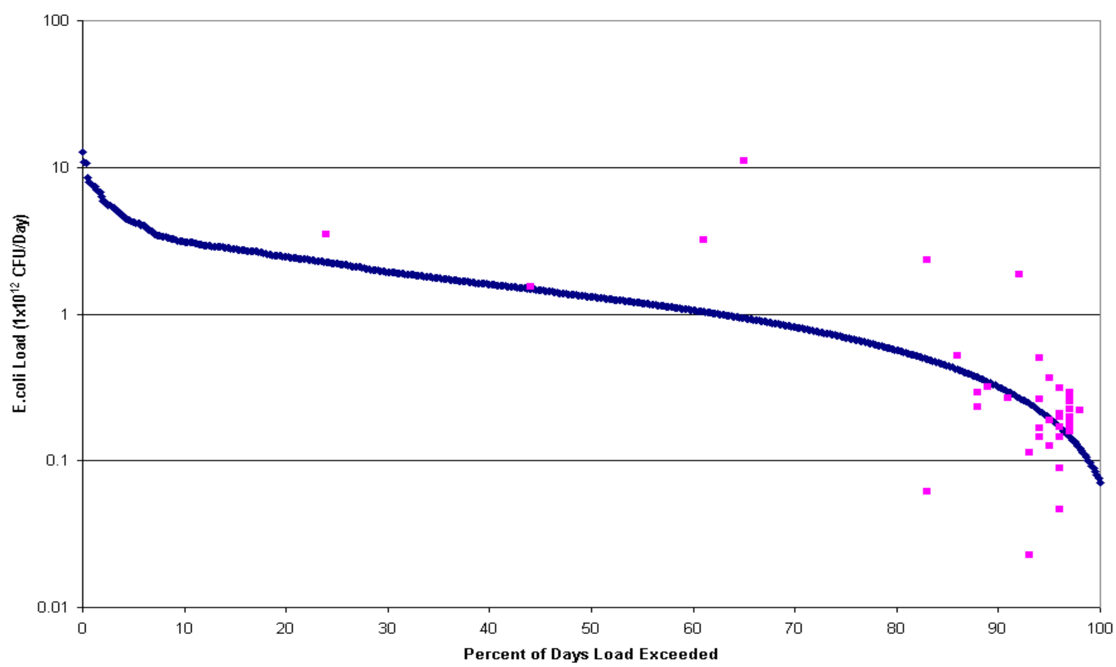


FIGURE 15
LOAD DURATION CURVE FOR ITF SITE #210



4.4.2 ITF #224 Load Duration Analysis

The next sample location is just upstream of the gage at the Midwest Steel Outfall. The load-duration curve (Figure 17) shows that all samples collected have been below the state standard for *E.coli*. This shows that the concentrations are likely being diluted temporarily by "fresh" water discharge from the steel mills. *E.Coli* concentrations then recover some once they reach LMG060-0006.

4.4.3 Other Sites [LMG060-0012, BD-1 (ITF #223), LMG060-0007 and ITF #222 (ITF #235)]

The other load duration curves created, for sites LMG060-0012, BD-1 (ITF #223), LMG060-0007 and ITF #222 (ITF #235), are not shown. These locations had the same trend as Figure 16. This tends to support that both point and non point sources are contributing to the pollutant load and the sources are mostly coming from the watershed, not at the industrial area at the mouth of the watershed.

4.5 Deep River

Deep River is a large tributary of the west branch of the Little Calumet River. Deep River joins with the Little Calumet River as they meet to form Segment 24 of the Portage Burns Waterway.

4.5.1 ITF #218 Load Duration Analysis

The flow duration curve was developed for Deep River using the period of record (1947-2001) for the Lake George Outfall Gage (USGS #04093000). ITF Site #218 is also located at the Lake George Outfall. Figure 18 shows the load-duration curve for this site. The curve for the gage does not have the same trend as the other curves have had. It is believed that this because the flow through the dam is not natural but is controlled. The samples collected at this site were predominately above the state standard. As before this indicates either point sources or chronic pollution. There are nine point sources located upstream from Lake George. However, only three facilities are required to report bacteria discharges, IN0043907-Community Utilities of Gary, IN0025763-Crown Point Municipal STP, and IN0031771-John Wood Elementary School. The closest facility, Community Utilities of Gary, is located approximately eight miles upstream, on Turkey Creek, from the sample site.

4.5.2 ITF #219 Load Duration Analysis

Another sample site along Deep River that a load duration curve was developed for is ITF Site #219. This sample site is located approximately 2.5 miles downstream from the Lake George outfall and approximately 5 miles upstream from the mouth. Figure 19 shows the load-duration curve for this site. Since this site is located downstream of the USGS gage a ratio was determined based on the drainage area at the Lake George Outfall Gage (124 mi^2) and at Site #219 (142.6 mi^2). The trend at this site is similar to Site 218 (Figure 14). Most of the samples occurred above the state standard. There does appear to be a slight shift downward (an improvement in water quality) during lower flows. This is possibly showing the natural die-off of bacteria.

4.6 Portage Burns Waterway (Segment 24) Load-Duration Analysis

The load-duration curve was developed using the period of record (1943-1989) for USGS Gage at Gary (#04093500). However, since this gage is no longer active the flow record was extended using the flow record of the USGS gage at Lake George. The correlation between the gage at Gary and the Deep River gage at the Lake George has an correlation coefficient ($R^{2)}$ of 94 percent. The west branch of Little Calumet River flows both towards Illinois and towards the Portage Burns Waterway. The dividing line for the flow is not a defined point; it varies with flow

FIGURE 16
LOAD DURATION CURVE FOR LMG060-0006 (ITF SITE 225)

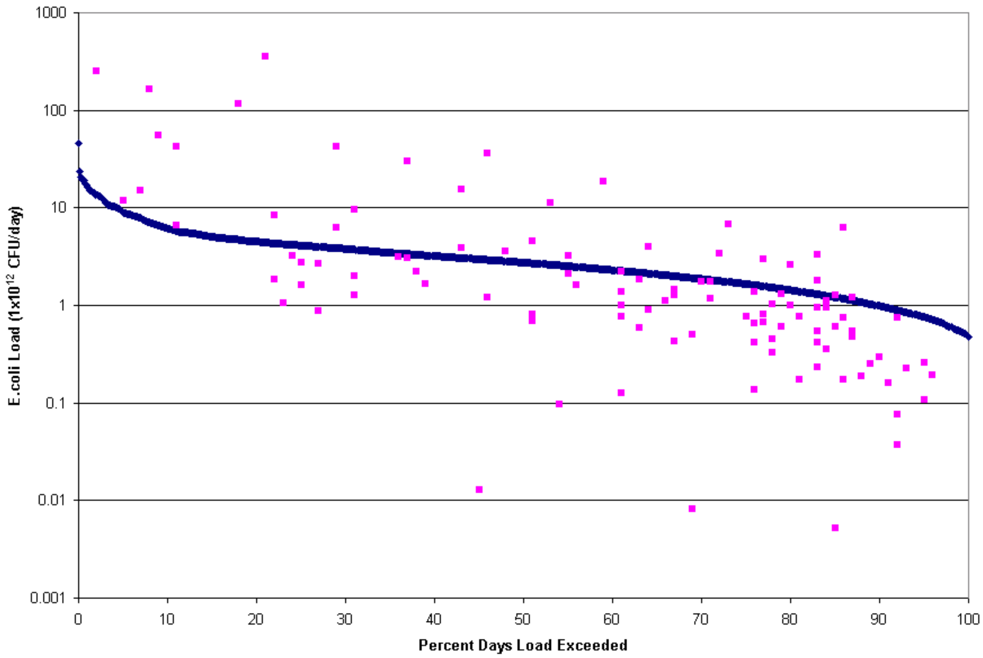


FIGURE 17
LOAD DURATION CURVE FOR ITF SITE #224

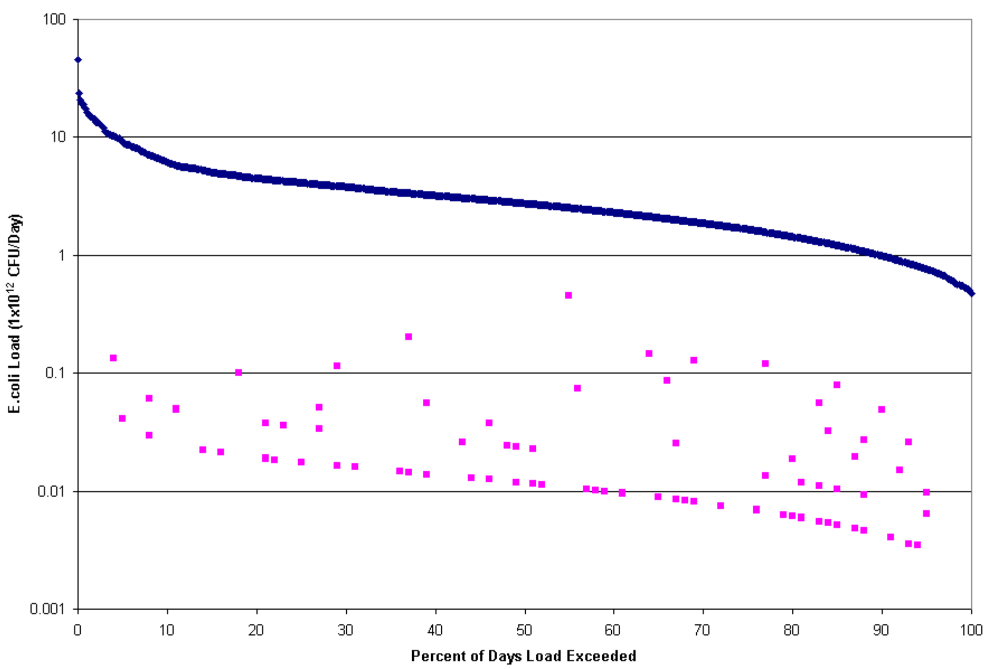


FIGURE 18
LOAD DURATION CURVE FOR LAKE GEORGE OUTFALL FOR ITF SITE #218

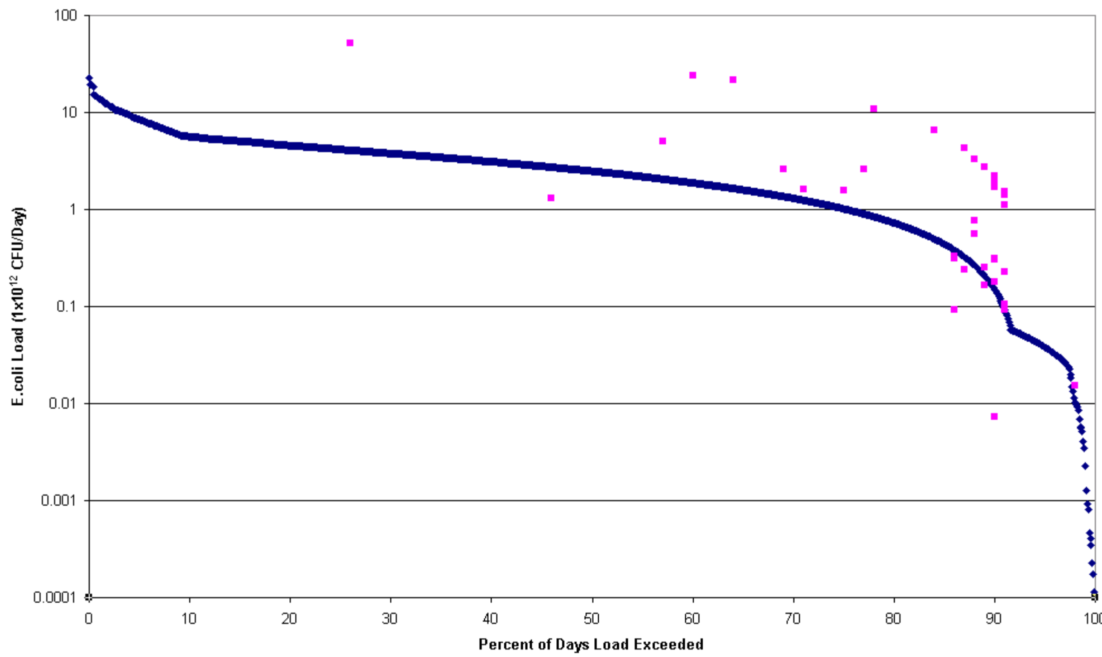
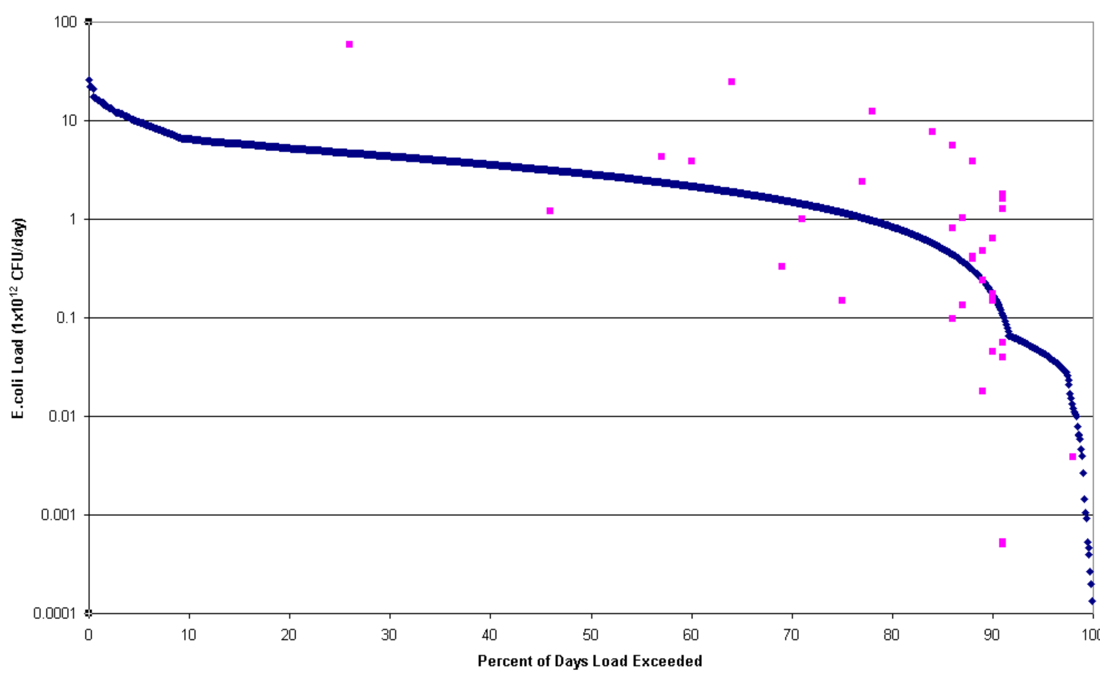


FIGURE 19
LOAD DURATION CURVE FOR ITF SITE #219



conditions and Lake Michigan water level. However, on average Deep River contributes about 70 percent of the flow at the Gary gage. Figure 20 shows the scatter plot used to determine the relationship between the two gages.

ITF Site #216 is located just downstream from the Gary gage at the Clay Street Bridge. In addition to the data collected by the ITF, this location is also a sample site (B9) for the GSD (Figure 3). Looking at the load duration curve for the site (Figure 21), it is seen that the loads follow a similar pattern as has been seen at the other monitoring sites. There are no known NPDES facilities that discharge bacteria into this portion of the River, except for those previously mentioned on Deep River. Therefore, this seems to indicate that the loads seen here are from a nonpoint source locally and from both the point and nonpoint sources in the Deep River watershed.

4.7 West Branch Little Calumet River (Segment 23)

The flow duration curve for the West Branch of Little Calumet River was determined using the USGS gage at Munster (05536195). The curve was developed using data from the period of record at the site (1958-2001). There are two sample locations near this gage that had samples analyzed for cyanide: UMC030-0001 and LCR-13 (UMC030-0004).

4.7.1 UMC030-0001 Load-Duration Analysis

UMC030-0001 is an IDEM station that is located at Manor Avenue and Hollywood Avenue in Munster. This sample location only had one sample that detected cyanide (August, 2000). This graph is not shown since no trend could be determined from the one sample. It is noted that the value was 0.0076 mg/L, which is greater than the standard. This location was also sampled two more times in June and again in August 2000, but neither sample had detected cyanide.

4.7.2 UMC030-0004 (LCR-13) Load-Duration Analysis

LCR-13 and UMC030-0004 is an IDEM sample site located at Hohman Avenue Bridge in Hammond. The load-duration curve for cyanide (Figure 22) for this site shows that most samples exceeded the state standard for cyanide. It also shows that cyanide loads generally do not exceed 1.0×10^7 mg/day, regardless of the flow condition in the river. This would tend to show that a point source is contributing to the impairment or it is a chronic watershed problem. There are no NPDES facilities that report discharging cyanide to the watershed. Therefore, it is believed that there is either an undocumented point source or it is groundwater leaching cyanide from contaminated fill or contaminated sediments in the water course (nonpoint sources).

FIGURE 20
COMPARISON BETWEEN DEEP RIVER GAGE AND PORTAGE-BURNS WATERWAY GAGE

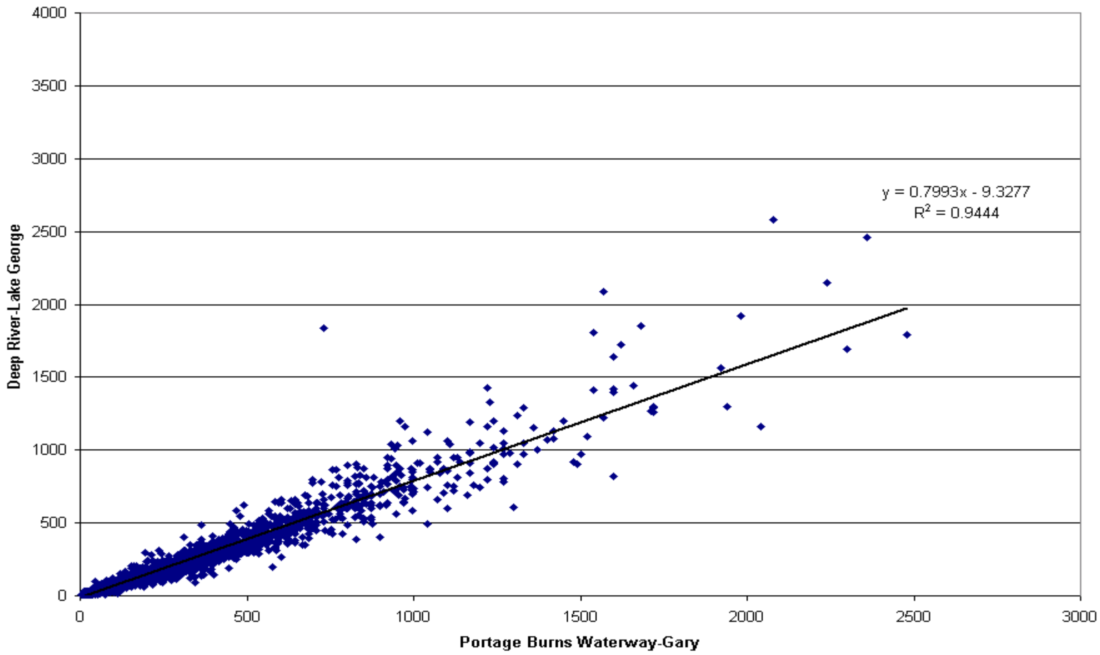


FIGURE 21
LOAD DURATION CURVE FOR ITF SITE #216 (GSD 9B)

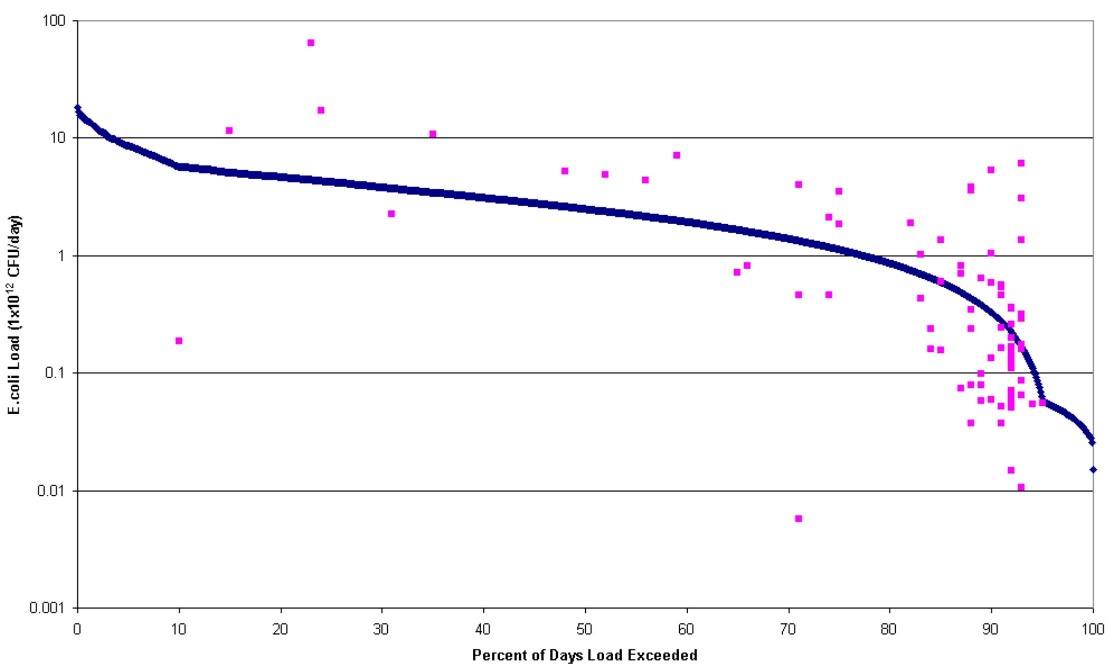
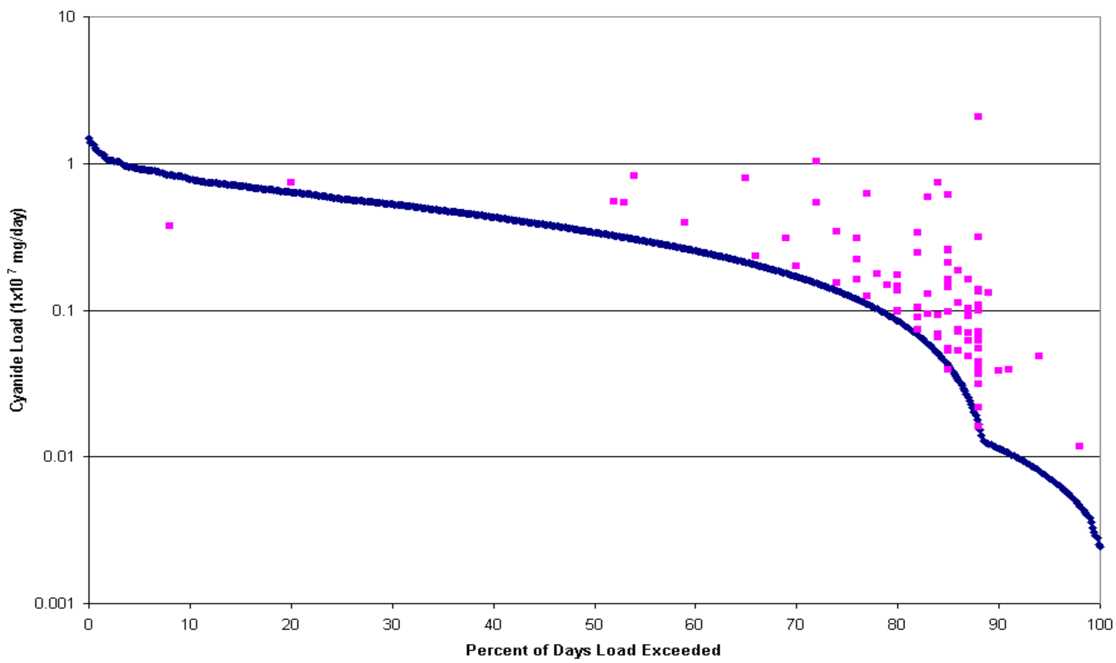


FIGURE 22
LOAD DURATION CURVE FOR CYANIDE FOR LCR-13 (UMC030-0004)



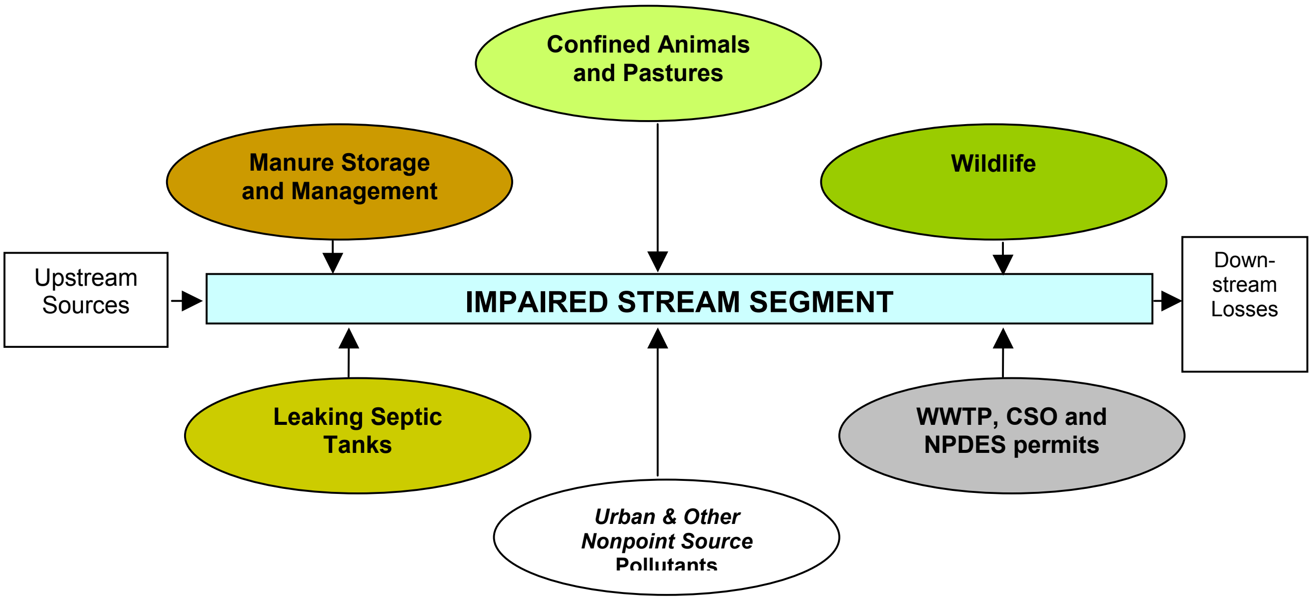
5. SUMMARY

Development of the TMDL requires that the fate and transport of the each of the pollution sources in Figure 23 be understood and defined.

For the *E.coli* TMDL there seems to be reasonable documentation of WWTP and other NPDES permits. There appears to no contribution from Manure Management and Confined Animals. However based on the available information for the watershed, that has been presented in this document, the contribution from urban nonpoint source runoff, wildlife and leaking septic remains unknown, but there are methodologies for estimating a general loads. Nonpoint sources appear to be a major source of *E.coli* impairment. The top three likely sources of nonpoint source pollution are: urban stormwater runoff, leaking/failing septic tanks and wildlife. Some monitoring data seems to indicate that point sources are major contributors of impairment. However, discharge reports from the point sources do not appear to support this conclusion.

For cyanide, there are no documented sources. Further analysis of the available data, additional collection of existing data and possibly additional field investigations may be needed. The possible source of cyanide is believed to be an undocumented point source, groundwater leaching cyanide from contaminated fill or contaminated sediments in the water course.

Figure 23 TMDL Model Simulation Processes



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